

## PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-241192

(43)Date of publication of application : 28.08.2002

(51)Int.Cl.

C30B 25/18

C30B 29/38

H01L 21/205

// H01L 33/00

(21)Application number : 2001-036604

(71)Applicant : TOYODA GOSEI CO LTD  
TOYOTA CENTRAL RES & DEV LAB  
INC

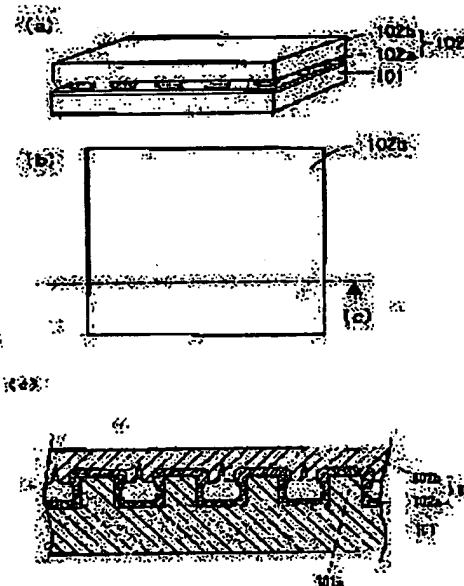
(22)Date of filing : 14.02.2001

(72)Inventor : NAGAI SEIJI  
TOMITA KAZUYOSHI(54) METHOD FOR PRODUCING SEMICONDUCTOR CRYSTAL AND SEMICONDUCTOR LIGHT  
EMITTING ELEMENT

## (57)Abstract:

PROBLEM TO BE SOLVED: To obtain a high quality semiconductor crystal nearly free from dislocations.

SOLUTION: When a substrate layer (a desired semiconductor crystal) of a group III nitride-based compound is grown on a ground substrate having a plurality of projection parts, cavities where no semiconductor crystal is deposited are formed at each of spaces between the projected parts, depending on the size of each projected part, the distance between the projected parts, crystal growth conditions, or the like. Therefore, when the thickness of the substrate layer is made sufficiently larger than the height of the projected parts, an internal stress or an external stress tends to act on the projected parts in a concentrated manner. These stresses act especially on the projected parts as the shear stress, and when the stresses become large enough, fracture occurs at the projected parts. Accordingly, it becomes possible to easily separate the ground substrate and the substrate layer by the use of these stresses and to obtain the semiconductor crystal independent from the ground substrate. The stresses are more easily concentrated on the projected parts as the sizes of the cavities become larger, and it becomes possible to separate the substrate layer from the ground substrate without failure.



## LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

Copyright (C); 1998,2000 Japan Patent Office



## \* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

---

**CLAIMS**


---

**[Claim(s)]**

**[Claim 1]** The manufacture method of a semiconducting crystal characterized by providing the following: A longitudinal direction crystal-growth operation is used and it is on a ground substrate. Height formation process which is the method of obtaining the semiconducting crystal which became independent of the aforementioned ground substrate by forming the substrate layer which consists of an III group nitride system compound semiconductor, and forms many heights on the aforementioned ground substrate. The crystal-growth process to which the crystal growth of the aforementioned substrate layer is carried out until this growth side is mutually connected respectively as first growth side where the aforementioned substrate layer starts a crystal growth and it grows up to be a series of abbreviation flat surfaces at least in a part of front face [ at least ] of the aforementioned height. The partition stage which separates the aforementioned substrate layer and the aforementioned ground substrate by fracturing the aforementioned height.

**[Claim 2]** The manufacture method of the semiconducting crystal according to claim 1 characterized by generating the stress based on the coefficient-of-thermal-expansion difference of the aforementioned substrate layer and the aforementioned ground substrate, and fracturing the aforementioned height by cooling or heating the aforementioned substrate layer and the aforementioned ground substrate using this stress.

**[Claim 3]** A longitudinal direction crystal-growth operation is used and it is on a ground substrate. By forming the substrate layer which consists of an III group nitride system compound semiconductor The height formation process which is the method of obtaining a semiconducting crystal and forms many heights on the aforementioned ground substrate, A part of front face [ at least ] of the aforementioned height until this growth side is connected mutually respectively and it grows up to be a series of abbreviation flat surfaces at least as first growth side where the aforementioned substrate layer starts crystal growth Have the crystal-growth process to which the crystal growth of the aforementioned substrate layer is carried out, and it sets at the aforementioned crystal-growth process. Above By adjusting the amount q of feeding of an III group nitride system compound semiconductor The manufacture method of the semiconducting crystal characterized by controlling the difference (b-a) of the rate of crystal growth a of the aforementioned III group nitride system compound semiconductor in some [ at least ] exposed regions of the trough between the aforementioned heights of the aforementioned ground substrate, and the rate of crystal growth b in the parietal region of the aforementioned height to abbreviation maximum.

**[Claim 4]** It describes above in the aforementioned crystal-growth process. The claim 1 characterized by controlling the difference (b-a) of the rate of crystal growth a of the aforementioned III group nitride system compound semiconductor in some [ at least ] exposed regions of the trough between the aforementioned heights of the aforementioned ground substrate, and the rate of crystal growth b in the parietal region of the aforementioned height to abbreviation maximum by adjusting the amount q of feeding of an III group nitride system compound semiconductor, or the manufacture method of a semiconducting crystal according to claim 2.

**[Claim 5]** They are 1micromol / min about the aforementioned amount q of feeding. They are 100micromol / min above. The claim 3 characterized by considering as the following, or the manufacture method of a semiconducting crystal according to claim 4.

**[Claim 6]** The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by using silicon (Si) or carbonization silicon (SiC) as a material of the aforementioned ground substrate, or a claim 5.

[Claim 7] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by forming the aforementioned height in the aforementioned height formation process, using Si (111) as a material of the aforementioned ground substrate so that Si (111) side may not be exposed to the exposed region of the trough between the aforementioned heights of the aforementioned ground substrate, or a claim 6.

[Claim 8] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by having the process which forms in the front face of the aforementioned height at least the buffer layer which consists of " $\text{Al}_x\text{Ga}_{1-x}\text{N}$  ( $0 < x \leq 1$ )" after the aforementioned height formation process, or a claim 7.

[Claim 9] The manufacture method of the semiconducting crystal according to claim 8 characterized by forming the thickness of the aforementioned buffer layer below in the lengthwise height of the aforementioned height.

[Claim 10] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by setting thickness of the aforementioned substrate layer to 50 micrometers or more in the aforementioned crystal-growth process, or a claim 9.

[Claim 11] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by changing a crystal-growth method into the quick crystal-growth method of the rate of crystal growth on the way from the late crystal-growth method of the rate of crystal growth in the aforementioned crystal-growth process, or a claim 10.

[Claim 12] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by forming the aforementioned height in the aforementioned height formation process so that the aforementioned height may be arranged abbreviation regular intervals or an abbreviation fixed period, or a claim 11.

[Claim 13] The manufacture method of the semiconducting crystal according to claim 12 characterized by forming the aforementioned height in the aforementioned height formation process on the lattice point of the two-dimensional triangular grid to which one side makes the keynote the abbreviation equilateral triangle of 0.1 micrometers or more.

[Claim 14] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by forming the horizontal section configuration of the aforementioned height in an abbreviation equilateral triangle, an approximate regular hexagon, an approximate circle form, or a square in the aforementioned height formation process, or a claim 13.

[Claim 15] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by setting the arrangement interval of the aforementioned height to 0.1 micrometers or more and 10 micrometers or less in the aforementioned height formation process, or a claim 14.

[Claim 16] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by setting the lengthwise height of the aforementioned height to 0.5 micrometers or more and 20 micrometers or less in the aforementioned height formation process, or a claim 15.

[Claim 17] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by setting the size of the longitudinal direction of the aforementioned height, width of face, or a diameter to 0.1 micrometers or more and 10 micrometers or less in the aforementioned height formation process, or a claim 16.

[Claim 18] Before the aforementioned crystal-growth process, by physical processing of optical processing, such as various etching, electron-beam-irradiation processing, and laser, chemical preparation or cutting, polish, etc. By deteriorating or changing the crystallinity of some [ at least ] exposed regions of the trough between the aforementioned heights of the aforementioned ground substrate, or the molecular structure The above in the aforementioned exposed region The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by reducing the rate of crystal growth a of an III group nitride system compound semiconductor, or a claim 17.

[Claim 19] In the state [ leaving the substrate which consists of the aforementioned ground substrate and the aforementioned substrate layer to the reaction chamber of growth equipment in the aforementioned partition stage, and having passed the ammonia ( $\text{NH}_3$ ) gas of abbreviation constant flow to the aforementioned reaction chamber ] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by cooling the aforementioned substrate to abbreviation ordinary temperature with the cooling rate about " $-100$  degree-C/min— $0.5$  degree C/min" in general, a claim 2, a claim 4, or a claim 18.

[Claim 20] The manufacture method of a semiconducting crystal given in any 1 term of the claim 1 characterized by having the wreckage removal process that chemical or physical processing processing

of etching etc. removes at least the fracture wreckage of the aforementioned height which remained a the rear face of the aforementioned substrate layer after the aforementioned partition stage, a claim 2 a claim 4, or a claim 19.

[Claim 21] It is characterized by having the aforementioned semiconducting crystal manufactured by any 1 term of a claim 1 or a claim 20 using the manufacture method of the semiconducting crystal a publication as a crystal-growth substrate. III group nitride system compound semiconductor light emitting device.

[Claim 22] It is characterized by what was manufactured by the crystal growth which used as the crystal-growth substrate the aforementioned semiconducting crystal manufactured by any 1 term of a claim 1 or a claim 20 using the manufacture method of the semiconducting crystal a publication. III group nitride system compound semiconductor light emitting device.

---

[Translation done.]

## \* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.

2. \*\*\* shows the word which can not be translated.

3. In the drawings, any words are not translated.

---

## DETAILED DESCRIPTION

---

### [Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention uses a longitudinal direction crystal-growth operation, and is on a ground substrate. It is related with the manufacture method of a semiconducting crystal of obtaining a crystal-growth substrate, by forming the substrate layer which consists of an III group nitride system compound semiconductor.

[0002]

[Description of the Prior Art] If the crystal growth of the nitride semiconductors, such as a gallium nitride (GaN), is carried out on the ground substrate which consists of silicon (Si) etc. and it cools to ordinary temperature after that so that it may illustrate to drawing 5 for example, generally it is known that many transposition and cracks will go into a nitride semiconductor layer.

[0003]

[Problem(s) to be Solved by the Invention] Thus, when many transposition and cracks went into the growth phase (nitride semiconductor layer) and a device is produced on it, it becomes the cause which brings a result which many a lattice defect, transposition, deformation, cracks, etc. produce, and causes degradation of a device property into a device. Moreover, the ground substrate which consists, for example of silicon (Si) etc. is removed, and when it is going to leave only a growth phase and is going to obtain the independent substrate (crystal), the thing of a large area (more than 1cm<sup>2</sup>) is not obtained by operation of the above-mentioned transposition, a crack, etc.

[0004] It is that accomplish this invention in order to solve the above-mentioned technical problem, and the purpose does not have a crack, and the density of transposition obtains the semiconducting crystal (crystal-growth substrate) of low high quality.

[0005]

[A The means for solving a technical problem, an operation, and an effect of the invention] The following means are effective in order to solve the above-mentioned technical problem. Namely, the 1st means uses a longitudinal direction crystal-growth operation, and is on a ground substrate. In the manufacturing process which obtains the semiconducting crystal which became independent of a ground substrate by forming the substrate layer which consists of an III group nitride system compound semiconductor. The crystal-growth process to which the crystal growth of the substrate layer is carried out until this growth side is mutually connected with the height formation process which forms many heights on a ground substrate respectively in a part of front face [ at least ] of this height as first growth side where a substrate layer starts a crystal growth and it grows up to be a series of abbreviation flat surfaces at least, It is preparing the partition stage which separates a substrate layer and a ground substrate by fracturing a height.

[0006] however, to general "III group nitride system compound semiconductor" said here The semiconductor of the arbitrary mixed-crystal ratios expressed with 2 yuan, 3 yuan, or 4 yuan the general formula which  $Al_x Ga_y In_{(1-x-y)} N$  ( $0 \leq x \leq 1$ ,  $0 \leq y \leq 1$ ,  $0 \leq x+y \leq 1$ )  $N$  Changes is contained. Furthermore, also let the semiconductor with which p type or the n type impurity was added be the criteria of the "III group nitride system compound semiconductor" of this specification. Moreover, the above Let the semiconductor which replaced the part of the III group elements (aluminum, Ga, In) with boron (B), the thallium (Tl), etc., or replaced some nitrogen (N) by Phosphorus (P), arsenic (As), antimony (Sb), the bismuth (Bi), etc. be the criteria of the "III group nitride system compound semiconductor" of this specification. moreover — as the impurity of the above-mentioned p type — magnesium (Mg) — or calcium (calcium) etc. can be added Moreover, as an impurity of the above-mentioned n type, silicon

(Si), sulfur (S), selenium (Se), tellurium (Te) or germanium (germanium), etc. can be added, for example. Moreover, these impurities may add two or more elements simultaneously, and may add both molds (p type and n type) simultaneously.

[0007] For example, on the ground substrate which has many heights so that it may illustrate to drawing 1 When growing up the substrate layer (semiconducting crystal) which consists of an III group nitride system compound, formation of the "cavity" by which a laminating is not carried out of a semiconducting crystal is attained between each height (side of a height) by adjusting the size and arrangement interval of a height, crystal-growth terms and conditions, etc. For this reason, if substrate layer thickness is enlarged enough as compared with the height of a height, internal stress or external stress will become easy to act on this height intensively. When it acts as shearing stress to a height etc. and this stress becomes large, a height fractures the result, especially such stress. Therefore, if this stress is used, it will become possible to separate a ground substrate and a substrate layer easily (ablation). By this means, the crystal (substrate layer) which became independent of a ground substrate can be obtained. Moreover, it becomes easy to concentrate stress (shearing stress) on a height, so that the above-mentioned "cavity" is formed greatly.

[0008] moreover -- for example, the distortion based on [ since the contact part of a ground substrate and a substrate layer (or desired semiconducting-crystal layer) is narrowly limited by forming the above heights so that drawing 1 may also show ] both lattice constant difference -- being generated -- being hard -- "the stress based on the lattice constant difference between a ground substrate and a substrate layer" is eased For this reason, in case a substrate layer (desired semiconducting crystal) carries out a crystal growth, the unnecessary stress committed in the substrate layer under growth is suppressed, and the generating density of transposition or a crack is reduced.

[0009] In addition, in case a ground substrate and a substrate layer are separated (ablation), a part of substrate layer may remain in a ground substrate side, or a part of ground substrate (example : fracture wreckage of a height) may remain in a substrate layer side. Namely, the above-mentioned partition stage is not premised on perfect separation of each material which makes some wreckage of such material there be nothing (requirement).

[0010] Moreover, 2nd means to solve the above-mentioned technical problem is generating the stress based on the coefficient-of-thermal-expansion difference of a substrate layer and a ground substrate, and fracturing the above-mentioned height using this stress by setting for these 1st means, and cooling or heating a substrate layer and a ground substrate. According to this means, it becomes possible to generate the above-mentioned stress easily.

[0011] Moreover, the 3rd means uses a longitudinal direction crystal-growth operation, and is on a ground substrate. In the manufacturing process which obtains a semiconducting crystal by forming the substrate layer which consists of an III group nitride system compound semiconductor The crystal-growth process to which the crystal growth of the substrate layer is carried out until this growth side is mutually connected with the height formation process which forms many heights on a ground substrate respectively in a part of front face [ at least ] of this height as first growth side where a substrate layer starts a crystal growth and it grows up to be a series of abbreviation flat surfaces at least is established. In this crystal-growth process By adjusting the amount q of feeding of an III group nitride system compound semiconductor It can set to some [ at least ] exposed regions of the trough between the heights of a ground substrate. It is controlling the difference (b-a) of the rate of crystal growth a of an III group nitride system compound semiconductor, and the rate of crystal growth b in the parietal region of a height to abbreviation maximum.

[0012] According to this means, the rate of crystal growth near the parietal region of a height becomes large relatively, and the crystal growth near [ above ] an exposed region is suppressed comparatively, and becomes dominant [ the crystal growth from near the parietal region ]. Consequently, longitudinal direction growth (ELO) of the substrate layer started from near the parietal region of a height becomes remarkable, and "the stress based on the lattice constant difference between a ground substrate and a substrate layer" committed in a substrate layer at the time of the crystal growth of a substrate layer is eased. Therefore, the crystal structure of a substrate layer is stabilized and it is hard coming to generate transposition and a crack in a substrate layer. Moreover, if longitudinal direction growth (ELO) of a substrate layer becomes remarkable, a comparatively big cavity may be made in the side (between each height) of a height, for example.

[0013] For example, when irregularity is formed on the front face of a ground substrate a suitable size, an interval, or a period so that it may illustrate to drawing 1 , generally except the periphery part near the periphery side attachment wall of a ground substrate, the direction of the amount of supply per the

unit time and unit area of crystal material of a crevice (trough) tends to decrease compared with near the upper surface of heights (height). This inclination becomes possible [controlling the above-mentioned difference (b-a) to abbreviation maximum] by controlling these terms and conditions the optimal or suitably, although it depends in the flow rate of the gas stream of crystal material, temperature, the direction, etc.

[0014] Moreover, the 4th means can be set in the above 1st or the crystal-growth process of the 2nd means to some [at least] exposed regions of the trough between the heights of a ground substrate by adjusting the amount q of feeding of an III group nitride system compound semiconductor. It is controlling the difference (b-a) of the rate of crystal growth a of an III group nitride system compound semiconductor, and the rate of crystal growth b in the parietal region of a height to abbreviation maximum.

[0015] Also in this case, "the stress based on the lattice constant difference between a ground substrate and a substrate layer" committed in a substrate layer at the time of the crystal growth of a substrate layer is eased like the above-mentioned means, the crystal structure of a substrate layer is stabilized, and it is hard coming to generate transposition and a crack in a substrate layer. When longitudinal direction growth is remarkable, it becomes comparatively remarkable, so that a cavity is made by this operation and effect between each height (side of a height). Moreover, if a cavity is formed in the side (between each height) of a height, it will become easy to concentrate shearing stress on a height, and shearing stress will become easy to separate a ground substrate and a substrate layer in the above-mentioned partition stage. This operation and effect become remarkable, so that the cavity between each height (side of a height) becomes large.

[0016] Moreover, it sets for the above 3rd or the 4th means, and the 5th means is 1 micromol / min about the above-mentioned amount q of feeding. They are 100 micromol / min above. It is considering a the following.

[0017] The more desirable above-mentioned amount q of feeding is 5 micromol / min. They are 90 micromol / min above. The following is good. Furthermore, although it depends also on terms and conditions, such as specification of ground substrates, such as a size of the height formed, and a form, an arrangement interval, a kind of feed, and the direction of feeder current, a crystal-growth method, as a desirable value, they are 10-80 micromol / min in general. A grade is ideal. Since it will become difficult to control the above-mentioned difference (b-a) to abbreviation maximum if this value is too large, it becomes difficult to form a big cavity between each height (side of a height). As for the crystallinity of the single crystal of a substrate layer, it becomes easy to deteriorate and is not desirable to follow, in such a case for the stress in the crystal based on a lattice constant difference comparatively to be hard to be eased, and for transposition to occur etc.

[0018] moreover, the time of stress (shearing stress) separating a ground substrate and a substrate layer — a height — if there is no cavity of the side or this cavity is small — a height — stress — concentrating — being hard — fracture of a height is hard coming to happen and is not desirable. On the other hand, if the amount q of feeding is too small, crystal-growth time will be taken too much and it will become disadvantageous in respect of productivity, and it is not desirable.

[0019] Moreover, the 6th means is using silicon (Si) or carbonization silicon (SiC) as a material of a ground substrate in any the above 1st or 5th one means. moreover — as the material of other ground substrates — GaN, AlN, GaAs, InP, GaP, MgO and ZnO, and MgAl<sub>2</sub>O<sub>4</sub> etc. — it is useful and sapphire, a spinel, manganese oxide, an oxidation gallium lithium (LiGaO<sub>2</sub>), a molybdenum sulfide (MoS), etc. are usable. However, when separating a ground substrate and a substrate layer using the shearing stress based on a coefficient-of-thermal-expansion difference, it is desirable to choose the combination to which the coefficient-of-thermal-expansion difference between both material does not become small, and it is desirable to choose as a ground substrate side the material to which fracture tends to take place.

[0020] Moreover, the 7th means is forming a height, using Si (111) as a material of a ground substrate, so that Si (111) side's may not be exposed to the exposed region of the trough between the heights of a ground substrate in a height formation process in any the above 1st or 6th one means. According to this means, since the rate of crystal growth a of the exposed surface of the above-mentioned trough can be suppressed small, it becomes possible to carry out the abbreviation maximization of the above-mentioned difference (b-a) stably, with crystallinity maintained.

[0021] Moreover, the means of the octavus is establishing the process which forms the buffer layer which consists of "Al<sub>x</sub>Ga<sub>1-x</sub>N (0 < x ≤ 1)" on the surface of a height at least after the height formation process of any the above 1st or 7th one means.



[0022] however, the buffer layer of another further the above [ buffer layer / above-mentioned ] and the interlayer of \*\*\*\* composition (example : AlN and AlGa<sub>N</sub>) — other periodic or layers and alternati — or you may carry out a laminating so that multilayer structure may be constituted

[0023] The same operation principle as the former of being able to ease the stress committed in the substrate layer (growth phase) resulting from a lattice constant difference by the laminating of such a buffer layer (or interlayer) enables it to raise crystallinity.

[0024] Moreover, the 9th means is forming the thickness of a buffer layer below in the lengthwise height of a height in the means of the above-mentioned octavus. Moreover, as an absolute standard, the thickness of a buffer layer has about 0.01 micrometers or more and desirable 1 micrometer or 1 ss. By this means, only the crystal layer (example : GaN layer) of the request formed on a buffer layer can be grown up into a longitudinal direction good. That is, "the stress based on a lattice constant difference" applied to the crystal layer formed on a buffer layer at the time of a crystal growth is mitigated by this means, and dislocation density can decrease effectively by it.

[0025] According to the above-mentioned means [ like ] but which has the direction of GaN which is easy to be formed all over the abbreviation for the front face which the ground substrate exposed, and forms a desired crystal-growth layer etc. originally in the inclination which is easy to carry out longitudinal direction growth from AlN, AlGa<sub>N</sub>, etc., AlN which forms a buffer layer etc., AlGa<sub>N</sub>, etc. can form more certainly big a "cavity" in the side of a height.

[0026] Moreover, when a substrate layer is separated from a ground substrate, a crystal layer (layer of the request formed on a buffer layer) is broadly exposed also to the rear face (field of a side with the ground substrate) of a substrate layer soon with this means. Therefore, in case an electrode is formed in the rear face of a substrate layer, it becomes easy to suppress electric resistance.

[0027] In addition, the thickness of a buffer layer has 0.1 micrometers or more and good 0.5 micrometers or less more desirably, although about 0.01 micrometers — about 1 micrometer is as above mentioned a in general appropriate range. A cavity becomes easy to become small and is not desirable this thickness is too thick. Moreover, if this thickness is made thin too much, it will become difficult to form a buffer layer to abbreviation homogeneity. If the membrane formation nonuniformity (part which is not fully formed) of a buffer layer arises in near the upper part of a height especially, it becomes easy to produce nonuniformity also in crystallinity, and is not desirable.

[0028] Moreover, the 10th means is setting thickness of a substrate layer to 50 micrometers or more in the above 1st or the crystal-growth process of any 9th one means.

[0029] The tensile stress to a substrate layer is eased and the thickness of the substrate layer (III group nitride system compound semiconductor) which carries out a crystal growth can decrease the generating density of the transposition of a substrate layer, or a crack, so that about 50 micrometers or more are desirable and this thickness is thick. Furthermore, a substrate layer can be strengthened simultaneously and it becomes that it is easy to centralize the above-mentioned shearing stress on the above-mentioned height.

[0030] Moreover, the 11th means is changing a crystal-growth method into the quick crystal-growth method of the rate of crystal growth on the way from the late crystal-growth method of the rate of crystal growth in the above 1st or the crystal-growth process of any 10th one means.

[0031] For example, if the crystal-growth method (example : the MOVPE method) which is easy to make the above-mentioned difference (b-a) the abbreviation maximum is adopted and setting thickness to 50 micrometers or more efficiently after that adopts an easy crystal-growth method (example : the HVPE method) until a crystal-growth side grows into a series of abbreviation planes, it will become possible to obtain a crystalline good semiconducting crystal for a short time.

[0032] Moreover, the 12th means is forming the above-mentioned height so that a height's may be arranged abbreviation regular intervals or an abbreviation fixed period in the height formation process of any the above 1st or 11th one means.

[0033] Thereby, it becomes equal on the whole omitting the growth conditions of longitudinal direction growth, and it is hard coming to generate nonuniformity in a crystalline quality. moreover, the crystal-growth method the late crystal-growth method of the rate of crystal growth to the rate of crystal growth is quick since it is hard coming to generate local variation at time until the upper part of the trough between heights is completely covered by the substrate layer — on the way — the case where come out and a crystal-growth method is changed — the time — exact — an early stage — or it becomes easy it to be decided for that it will be a meaning Moreover, by this means, since the above-mentioned cavity serves as a size with an equal abbreviation respectively and becomes possible [ distributing the above-mentioned shearing stress to each height equally / abbreviation ], fracture of all

heights arises without nonuniformity and separation with a ground substrate and a substrate layer can carry out certainly.

[0034] Moreover, the 13th means is forming a height on the lattice point of the two-dimensional triangular grid to which one side's makes the keynote the abbreviation equilateral triangle of 0.1 micrometers or more in the height formation process of the 12th above-mentioned means. By this means, the 12th above-mentioned means can be carried out correctly and certainly more concretely, and, therefore, the number of transposition can be reduced certainly.

[0035] Moreover, the 14th means is forming the horizontal section configuration of a height in an abbreviation equilateral triangle, an approximate regular hexagon, an approximate circle form, or a square in the height formation process of any the above 1st or 13th one means. the direction of the crystallographic axis of the crystal formed from an III group nitride system compound semiconductor of this means — each part — a set — easy — arbitrary horizontal directions since it becomes — receiving — length with a horizontal height (size) — abbreviation — since it can restrict uniformly, the number of transposition can be suppressed Since especially a right hexagon and an equilateral triangle tend to agree with the crystal structure of a semiconducting crystal, they are more desirable. Moreover a round shape and a square have the merit compared with the present condition of the present general processing technical level referred to as being easy to form in respect of a manufacturing technology.

[0036] Moreover, the 15th means is setting the arrangement interval (arrangement period) of a height to 0.1 micrometers or more and 10 micrometers or less in the height formation process of any th above 1st or 14th one means. More desirably, although it is dependent also on the operation conditions of a crystal growth, the arrangement interval of a height has good about 0.5–8 micrometers. However, this arrangement interval means the distance between the central point of each height which approaches mutually.

[0037] While this means enables it to cover the upper part of the trough of a height in a substrate layer it becomes possible to form a cavity between heights. If this value is too small, an operation of ELO will no longer be obtained hardly and crystallinity will deteriorate. Unless the cavity formed becomes small too much and makes thickness of a substrate layer larger than required, it becomes moreover, less easy to fracture a height.

[0038] Moreover, if this value becomes large too much, it will become impossible to cover the upper part of the trough of a height in a substrate layer certainly, and a crystal (substrate layer) homogeneous [ crystallinity ] and good will no longer be obtained. If this value is still too larger, since the exposed surface of a trough will become vast too much, and an operation of ELO will hardly be obtained no longer and a cavity will no longer be formed at all, unless crystallinity deteriorates and thickness of a substrate layer is made larger than required, it becomes or less easy to fracture a height.

[0039] Moreover, the 16th means is setting the lengthwise height of a height to 0.5 micrometers or more and 20 micrometers or less in the height formation process of any the above 1st or 15th one means. More desirably, although it is dependent also on the operation conditions of a crystal growth, the lengthwise height of a height has good about 0.8–5 micrometers. If this height is too short, like the case where there is no height, an operation of ELO will no longer be obtained hardly and crystallinity will deteriorate. Moreover, if this height is too short, the above-mentioned cavity will no longer be formed. Moreover, if this height is too high, the formation of a height itself becomes difficult, formation of a height takes time more than required, or material of a ground substrate is consumed more than required and it is not desirable. Moreover, if this height is too high, it will become difficult for lengthwise [ of a height ] to distribute and for shearing stress to make a height fracture certainly.

[0040] Moreover, the 17th means is setting the size of the longitudinal direction of a height, width of face, or a diameter to 0.1 micrometers or more and 10 micrometers or less in the height formation process of any the above 1st or 16th one means. More desirably, although it is dependent also on the operation conditions of a crystal growth, the size of the longitudinal direction of a height, width of face, or a diameter has good about 0.5–5 micrometers. If this size is too thick, the influence of stress which works in a substrate layer (growth phase) based on a lattice constant difference will become large, and it will become easy to increase the number of dislocation of a substrate layer. Moreover, if too thin, the own formation of a height becomes difficult, or the rate of crystal growth b of the parietal region of a height becomes slow, and it is not desirable.

[0041] Moreover, if the size of the longitudinal direction of a height, width of face, or a diameter is too large in case a height is made to fracture with stress (shearing stress etc.), it becomes easy to produce the portion which is not fractured certainly, and is not desirable. Moreover, the size of the influence of stress which works in a substrate layer (growth phase) based on a lattice constant difference does not

depend only on the size (length) of the longitudinal direction of a height, and is dependent on the arrangement interval of a height etc. And if these setting ranges are unsuitable, the influence of stress based on a lattice constant difference becomes large as mentioned above, and it becomes easy to increase the number of dislocation of a substrate layer, and is not desirable.

[0042] Moreover, since there is an optimum value or a proper range in the size of the longitudinal direction near the parietal region of a height, width of face, or a diameter as mentioned above, the configuration of the upper surface of a height, a base, or a horizontal section has the configuration (the shape of an island) closed locally at least, and the configuration still better for it closed to convex toward the outside, and the configuration of this upper surface, a base, or a horizontal section has an approximate circle form, an abbreviation regular polygon good for it, etc. By such setup, it becomes easy certainly to arbitrary horizontal directions to realize an above-mentioned optimum value or the above-mentioned proper range.

[0043] Moreover, the 18th means is set for any the above 1st or 17th one means. Before a crystal-growth process, by physical processing of optical processing, such as various etching, electron-beam-irradiation processing, and laser, chemical preparation or cutting, polish, etc. By deteriorating or changing the crystallinity of some [ at least ] exposed regions of the trough between the heights of a ground substrate, or the molecular structure, it can set to this exposed region. It is reducing the rate of crystal growth of an III group nitride system compound semiconductor. By this means, difference (b-e) of the aforementioned rate of crystal growth can be enlarged more. Therefore, according to this means, since the rate of crystal growth near the parietal region of a height becomes large relatively, "the stress based on the lattice constant difference between a ground substrate and a substrate layer" committed in a substrate layer at the time of the crystal growth of a substrate layer is eased by the same operation as the above, and it is hard coming to generate dislocation and a crack in a substrate layer.

[0044] Moreover, in any one above-mentioned partition stage, the 19th means is in a state [ leaving the substrate which consists of a ground substrate and a substrate layer to the reaction chamber of growth equipment, and having passed the ammonia (NH<sub>3</sub>) gas of abbreviation constant flow to the reaction chamber ], and is cooling a substrate to abbreviation ordinary temperature with the cooling rate about "-100 degree-C/min—0.5 degree C/min" in general. For example, the aforementioned partition stage can be carried out by such means, maintaining the crystallinity of a substrate layer good.

[0045] Moreover, the 20th means is establishing at least the wreckage removal process chemical or physical processing processing of etching etc. removing the fracture wreckage of the height which remained in the rear face of a substrate layer, after any one above-mentioned partition stage. the current nonuniformity and the electric resistance which are produced near the interface of an electrode and a substrate layer when electrodes, such as a semiconductor light emitting device, are formed in the rear face (field of the side which made the ground substrate exfoliate) of a substrate layer according to this means — it can suppress — therefore — reduction of driver voltage — or improvement in luminescence intensity etc. can be aimed at

[0046] Furthermore, since the absorption of light near a mirror plane and dispersion are reduced and a reflection factor improves in case an electrode is used also as reflecting mirrors, such as a semiconductor light emitting device, by removing the fracture wreckage of a height, luminescence intensity improves. Moreover, since even the buffer layer of the rear face of a substrate layer can be removed or the flatness of the rear face of a substrate layer can also be improved when this wreckage removal process is carried out by physical processing processing of polish etc. for example, the above-mentioned operation effects, such as suppression of current nonuniformity or electric resistance, or the absorption of light near a mirror plane, reduction of dispersion, can be reinforced further.

[0047] Moreover, in the 21st means and an III group nitride system compound semiconductor light emitting device, it is having the semiconducting crystal manufactured using the manufacture method of the semiconducting crystal which depends on any the above 1st or 20th one means as a crystal-growth substrate. According to this means, it becomes crystallinity is good and more possible [ manufacturing an III group nitride system compound semiconductor light emitting device ] than a semiconductor with little internal stress, or easy.

[0048] Moreover, the 22nd means is manufacturing an III group nitride system compound semiconductor light emitting device by the crystal growth which used as the crystal-growth substrate the semiconducting crystal manufactured using the manufacture method of the semiconducting crystal which depends on any the above 1st or 20th one means. According to this means, it becomes crystallinity is good and more possible [ manufacturing an III group nitride system compound semiconductor light emitting device ] than a semiconductor with little internal stress, or easy. The

forementioned technical problem is solvable with the above means.

[0049]

[Embodiments of the Invention] Hereafter, this invention is explained based on a concrete example. However, this invention is not limited to the example shown below. Hereafter, the outline of the manufacture procedure of the semiconducting crystal (crystal-growth substrate) in the example of this invention is illustrated.

[0050] [1] As shown in the height formation process drawing 2, height 101a of the shape of an approximate circle pilaster with a diameter [ of about 1 micrometer ] and a height of about 1 micrometer was formed at intervals of about 2-micrometer arrangement by the dry etching using photo lithography on Si (111) side of the ground substrate 101 of the single crystal which consists of silicon. Height 101a was formed so that the center at the base of a pillar of height 101a might be arranged on each lattice point of the two-dimensional triangular grid which makes the keynote the abbreviation equilateral triangle whose one side is about 2 micrometers as an array form. However, thickness of the ground substrate 101 was set to about 200 micrometers.

[0051] [2] At the crystal-growth process book crystal-growth process, as shown in drawing 4, the growth process until a crystal-growth side is mutually connected respectively from the upper surface (initial state) of height 101a and grows up to be a series of abbreviation planes was carried out according to the organometallic compound vapor growth (the MOVPE method), and the growth process until it grows up to be the thick film this substrate layer (crystal layer) of whose is about 200 micrometers after that was carried out according to the hydride vapor growth (the HVPE method). In addition, at this crystal-growth process, it is ammonia (NH<sub>3</sub>). Gas, carrier gas (H<sub>2</sub>, N<sub>2</sub>), trimethylgallium (Ga<sub>3</sub> (CH<sub>3</sub>)) gas (it is described as "TMG" below), and trimethylaluminum (aluminum<sub>3</sub> (CH<sub>3</sub>)) gas (it is described as "TMA" below) were used.

[0052] (a) Organic washing and acid treatment washed first the ground substrate 101 ( drawing 2 ) in which the above-mentioned height 101a was prepared, the susceptor laid in the reaction chamber of crystal-growth equipment was equipped, and the ground substrate 101 was baked at the temperature of 1100 degrees C, passing H<sub>2</sub> to a reaction chamber by the ordinary pressure.

[0053] (b) Next, according to the MOVPE method, H<sub>2</sub>, and NH<sub>3</sub>, TMG and TMA were supplied on the above-mentioned ground substrate 101, and AlGa<sub>N</sub> buffer-layer (one layer of substrate \*\*\*\*) 102a was formed. The crystal-growth temperature of this AlGa<sub>N</sub> buffer-layer 102a was about 1100 degrees C, and thickness was about 0.3 micrometers. ( Drawing 3 )

(c) On this AlGa<sub>N</sub> buffer-layer (one layer of substrate \*\*\*\*) 102a, it is Ga<sub>N</sub> layer 102b of two layer of about 5 micrometers of a part of substrate \*\*\*\*, i.e., thickness, H<sub>2</sub> and NH<sub>3</sub> And TMG was supplied and the crystal growth was carried out at the growth temperature of 1075 degrees C. According to this process, as shown in drawing 4, two layer of a part of substrate \*\*\*\* (Ga<sub>N</sub> layer 102b) carried out longitudinal direction growth, and the big cavity was made in the side of trough, i.e., height, 101a. In addition, the TMG speed of supply at this time is 40micromol / min in general. It was a grade and the rate of crystal growth of two layer of substrate \*\*\*\* (Ga<sub>N</sub> layer 102b) was about about 1 micrometer/Hr.

[0054] (d) According to the hydride vapor growth (the HVPE method), the crystal growth of the above-mentioned Ga<sub>N</sub> layer (two layer of substrate \*\*\*\*) 102b was further carried out to 200 micrometers after that. The rate of crystal growth of Ga<sub>N</sub> layer 102b in this HVPE method was about about 45 micrometer/Hr.

[0055] [3] Partition stage (a) The ground substrate 101 and the substrate (it consists of AlGa<sub>N</sub> buffer-layer 102a and Ga<sub>N</sub> layer 102b) layer 102 were cooled to abbreviation ordinary temperature after the above-mentioned crystal-growth process, passing ammonia (NH<sub>3</sub>) gas to the reaction chamber of crystal-growth equipment. The cooling rate at this time was the "-50 degree-C/min—5 degree C/min" grade in general.

[0056] (b) When these were taken out from the reaction chamber of crystal-growth equipment after that, the Ga<sub>N</sub> crystal which exfoliated from the ground substrate 101 was obtained. However, this crystal was a thing [ that some / small / wreckage of AlGa<sub>N</sub> buffer-layer 102a and the fracture wreckage of height 101a have remained at the rear face of Ga<sub>N</sub> layer 102b ].

[0057] [4] The fracture wreckage of height 101a which consists of Si which remained in the rear face of a Ga<sub>N</sub> crystal by etching processing using the mixed liquor which added the nitric acid to fluoric acid was removed after the partition stage of the fracture wreckage removal process above.

[0058] By the above manufacture method, the semiconductor substrate of the good Ga<sub>N</sub> crystal of the crystallinity of about 200 micrometers of thickness which was very excellent (Ga<sub>N</sub> layer 102b), i.e., the

request which became independent of the ground substrate 101, was able to be obtained.

[0059] In addition, although the height and trough of a ground substrate are constituted from an above mentioned example by a vertical plane and the level surface as illustrated to drawing 2, you may form these from arbitrary slant faces, curved surfaces, etc. Therefore, the cross-section configuration of the trough formed on the ground substrate illustrated to drawing 2 (c) may be formed in the form of for example, the abbreviation type for U characters, the abbreviation type for V characters, etc. besides the \*\*\* type of an abbreviation rectangle, and, generally these configurations, a size, an interval, arrangement, orientation, etc. are arbitrary.

---

[Translation done.]

\* NOTICES \*

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.\*\*\* shows the word which can not be translated.

3.In the drawings, any words are not translated.

---

DESCRIPTION OF DRAWINGS

---

[Brief Description of the Drawings]

[Drawing 1] The typical perspective diagram of a partial fragment of the ground substrate explaining an operation of this invention which has a height, and the semiconducting crystal which grew on it.

[Drawing 2] The typical perspective diagram (a) of the partial fragment of the ground substrate (Si substrate) 101 concerning the example of this invention, a plan (b), and a cross section (c).

[Drawing 3] The typical perspective diagram (a) of the ground substrate 101 by which one layer (AlGaIn buffer layer) 102 of substrate \*\*\*\* a was formed, a plan (b), and a cross section (c).

[Drawing 4] The typical perspective diagram (a) of the ground substrate 101 to which the laminating of the substrate layer 102 (layer 102a and layer 102b) was carried out, a plan (b), and a cross section (c).

[Drawing 5] The typical cross section of the semiconducting crystal on the conventional ground substrate.

[Description of Notations]

101 — Ground Substrate (Si Substrate)

101a — Height

102 — Substrate Layer (Nitride Semiconductor Layer)

102a — One layer (AlGaIn buffer layer) of substrate \*\*\*\*

102b — Two layer (GaIn single crystal layer) of substrate \*\*\*\*

---

[Translation done.]